



Choice of flexibility sources towards a 100% renewable based Nordic energy system

Skytte, Klaus

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Flex4RES
Flexible Nordic Energy Systems



Choice of Flexibility sources towards a 100% renewable based Nordic energy system

System Resiliency and Flexibility
IEA EGRD
Vienna, May 2019

project coordinator:

Klaus Skytte

Klsk@dtu.dk

Energy Economics and Regulation
DTU, Department of Technology, Management and Economics,
Denmark



 **Nordic Energy
Research**

Towards 100% RES and Carbon Neutrality



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2020

-20%
Greenhouse
Gas Emissions

20%
Renewable
Energy

20% Energy
Efficiency

10%
Interconnection

2030

$\geq -40\%$
Greenhouse Gas
Emissions

$\geq 32\%$
Renewable
Energy

$\geq 32,5\%$
Energy Efficiency

15%
Interconnection

$\geq 14\%$
Renewables in
transport

Nordic long-term
decarbonisation
targets



Independent of
fossil fuels
2050



$\geq -80\%$
Greenhouse Gas
Emissions
2050



$\geq -50-75\%$
Greenhouse Gas
Emissions
2050



Carbon neutral
2050



No net greenhouse
gas emissions
2045

The Clean Energy Transition

Goals and RE-thinking of the energy infrastructure



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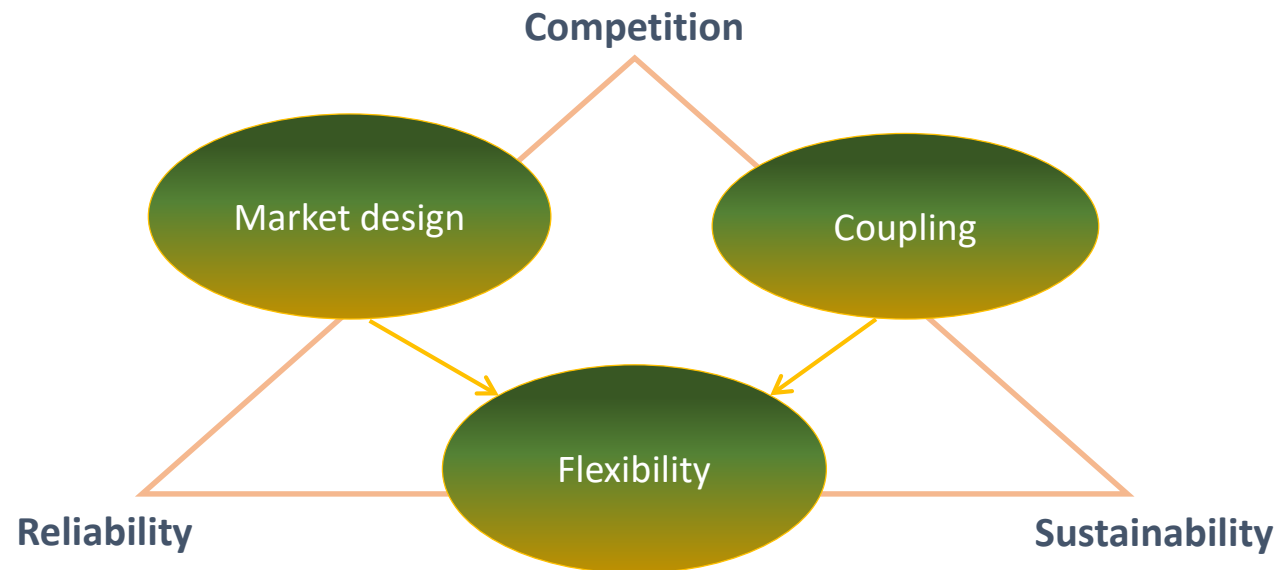
Current
electricity system

The trichotomy
of energy policy

Decarbonised
energy systems

Centralised fossil-
intensive supply

Electricity market
only



Decentralised
+
Variable
renewable energy
+
Phase-out of
fossil peakers

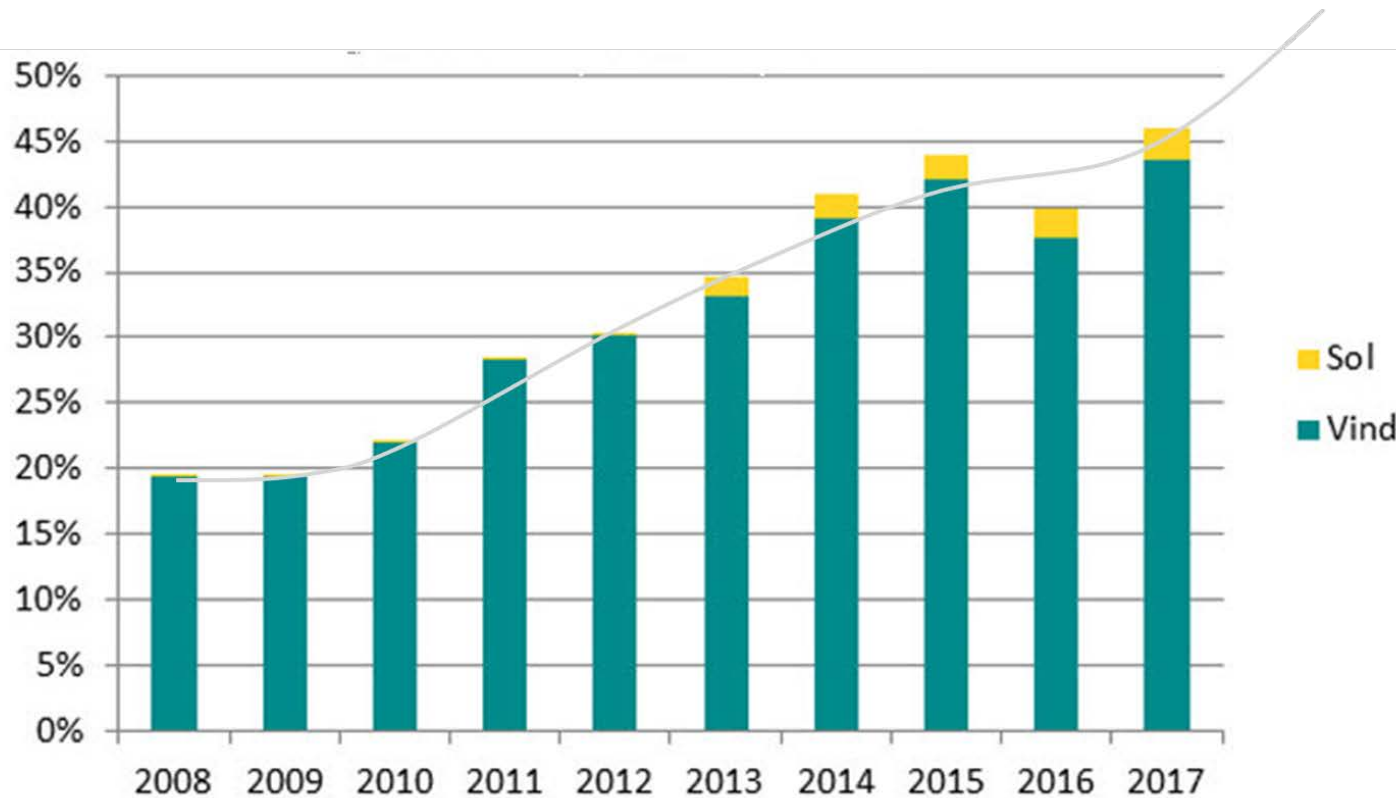
System integration



Example: Wind share in Denmark



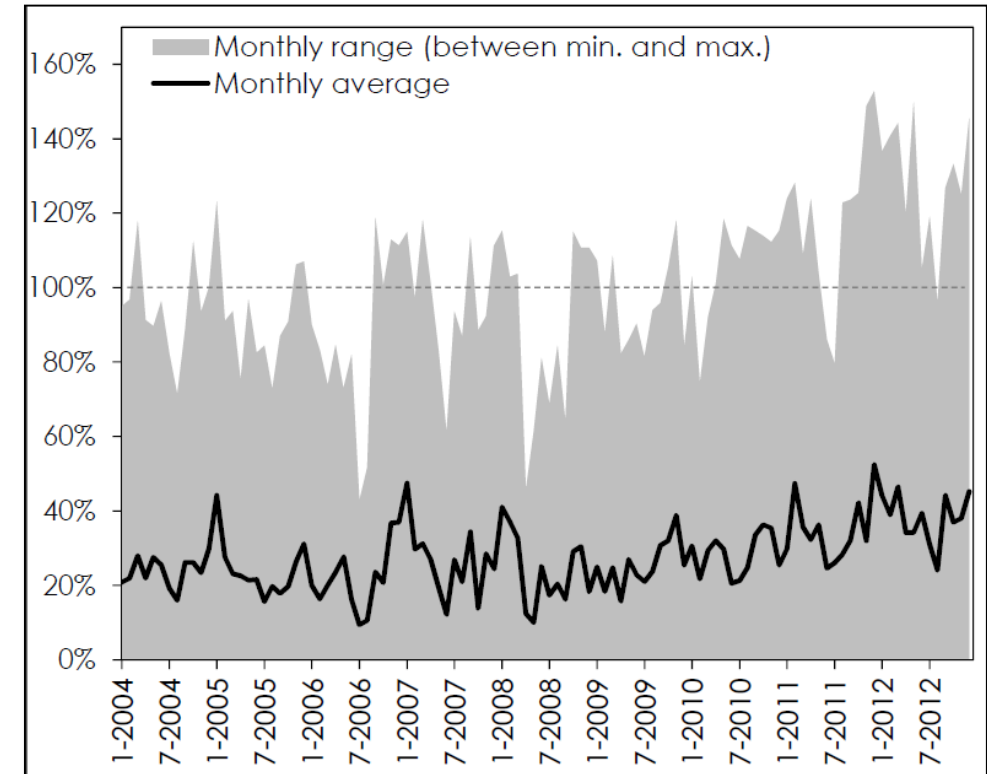
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Political target 2050:

The total energy supply based on renewable energy
incl. heat, gas, transport, industry, etc.

Wind production share in DK-West



23 December 2017: 1 hour with 139%

25 December 2017: 1 day with average of 109%

Need for Flexibility

Present Flexibility



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Adequate Flexibility Indicator

$$AFI = 1/(1+CV[p])$$

where

$$CV[p] = \sigma[p]/E[p]$$

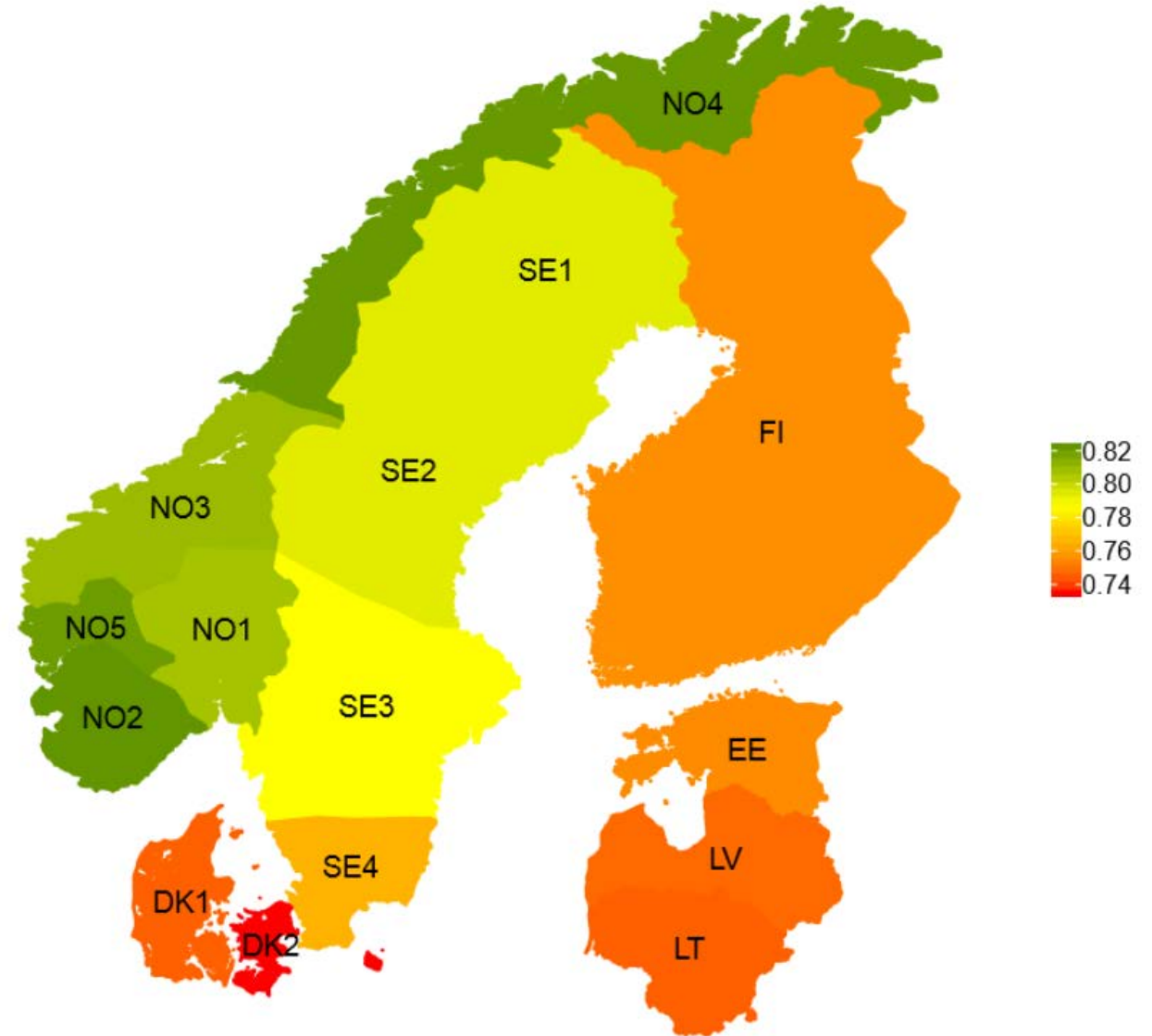
is the coefficient of variation of prices

AFI between 0 and 1

0 = no flexibility; infinitely volatile prices

1 = perfectly adequate flexibility; constant prices

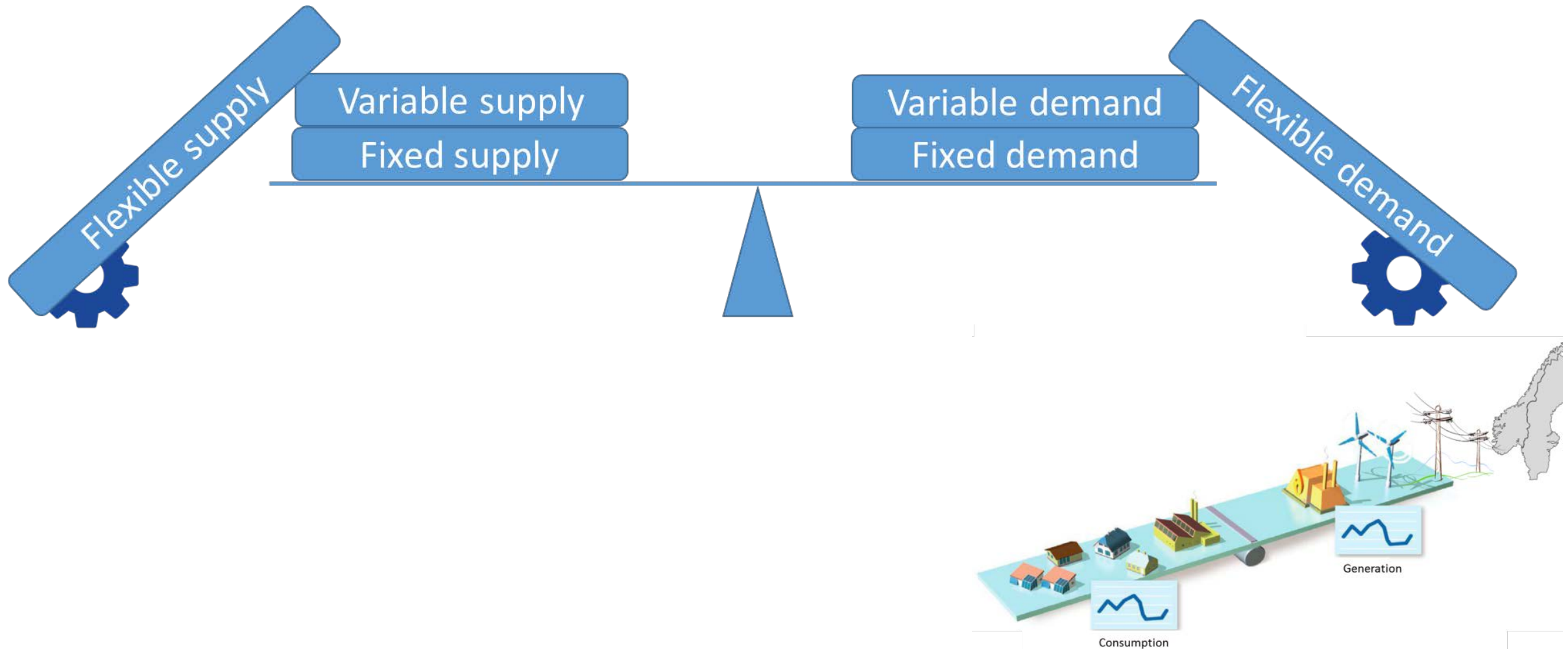
Nord Pool market prices 2018



Flexibility definition



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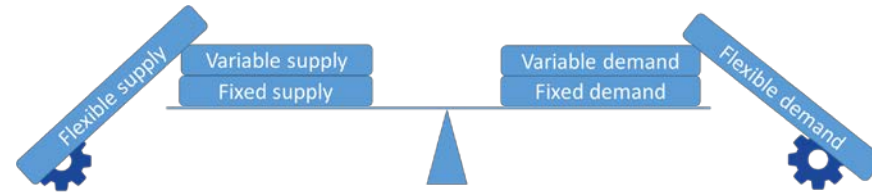
Supply and demand flexibility



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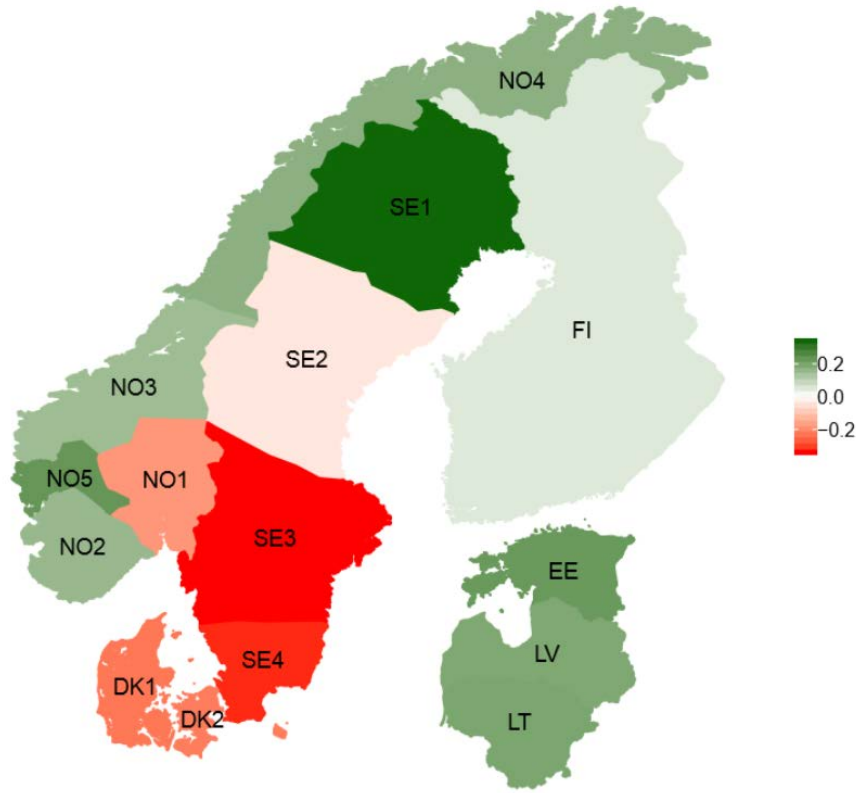
Supply side

$\text{Corr}[\text{Prod}; p]$

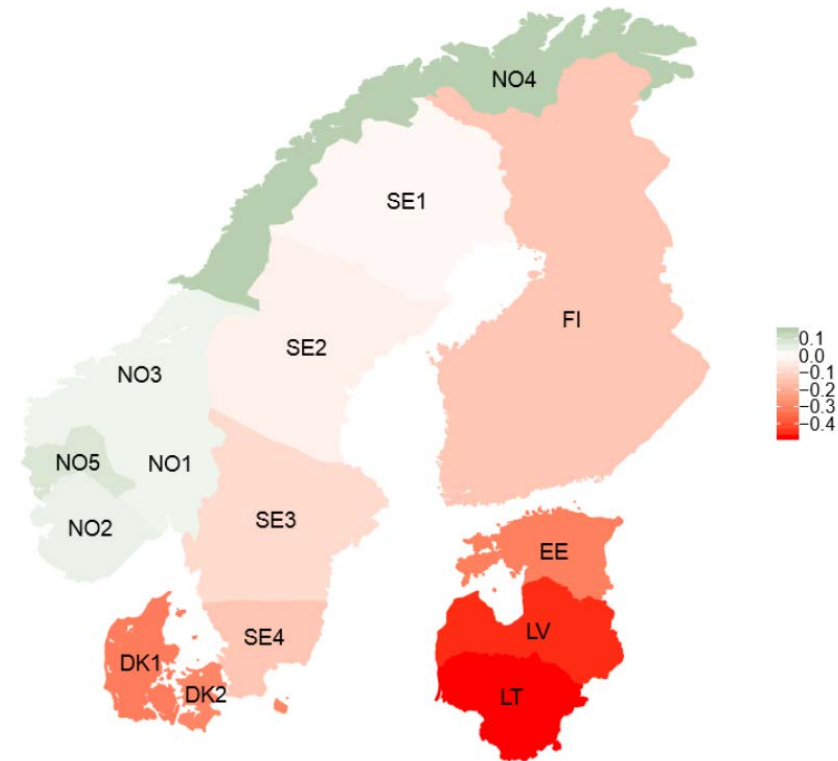


Demand side

$-\text{Corr}[\text{Cons}; p]$



Negative values indicate large influence of variable supply



Negative values indicate large influence of variable demand

Flexibility in electricity infrastructures



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Resource

Dispatchable

Variable

Trade

Supply flexibility

System

Electricity

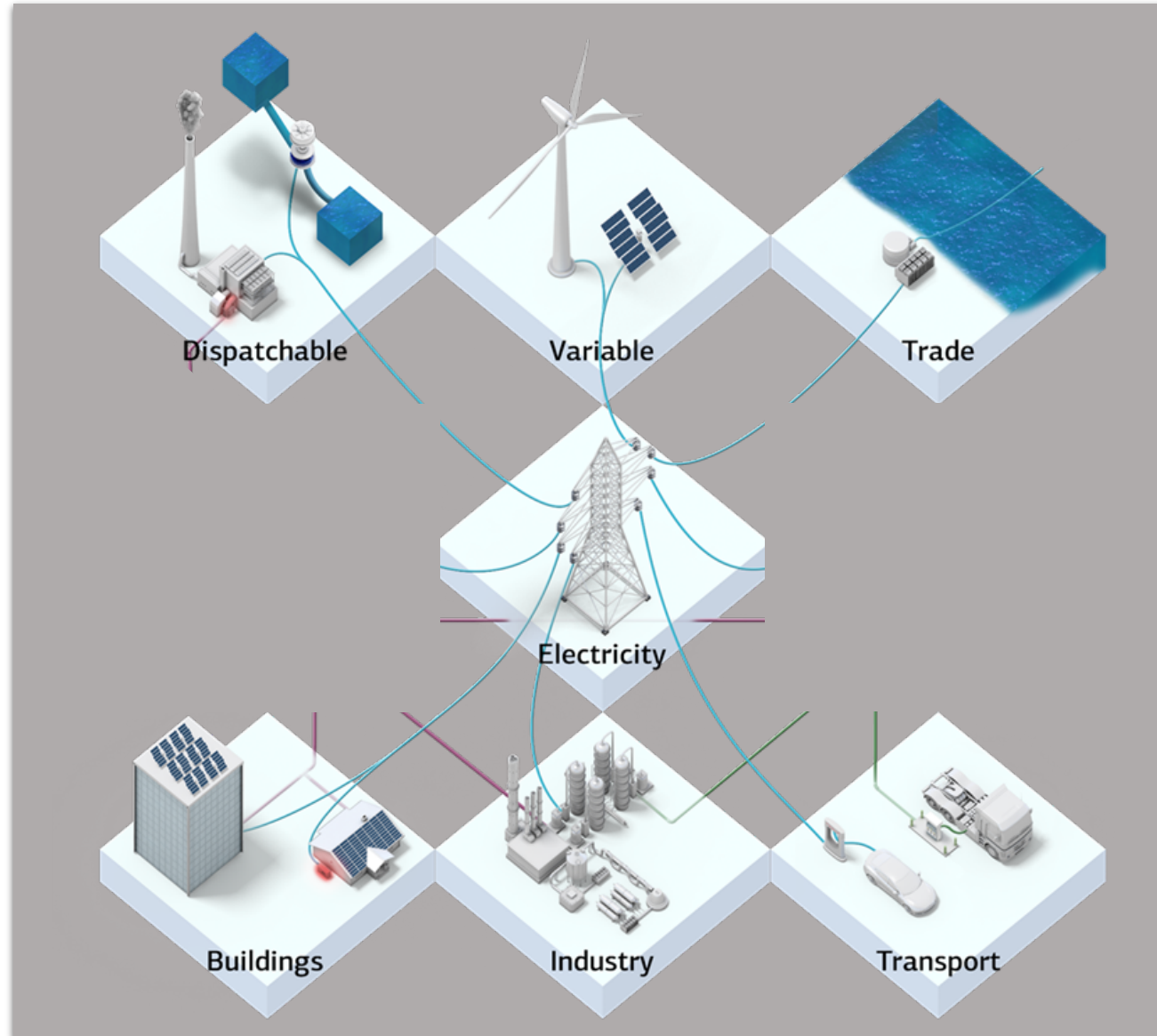
Service

Buildings

Industry

Transport

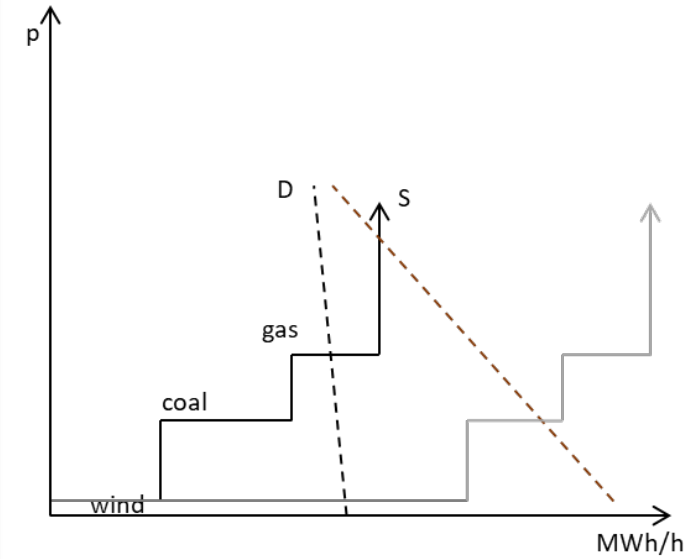
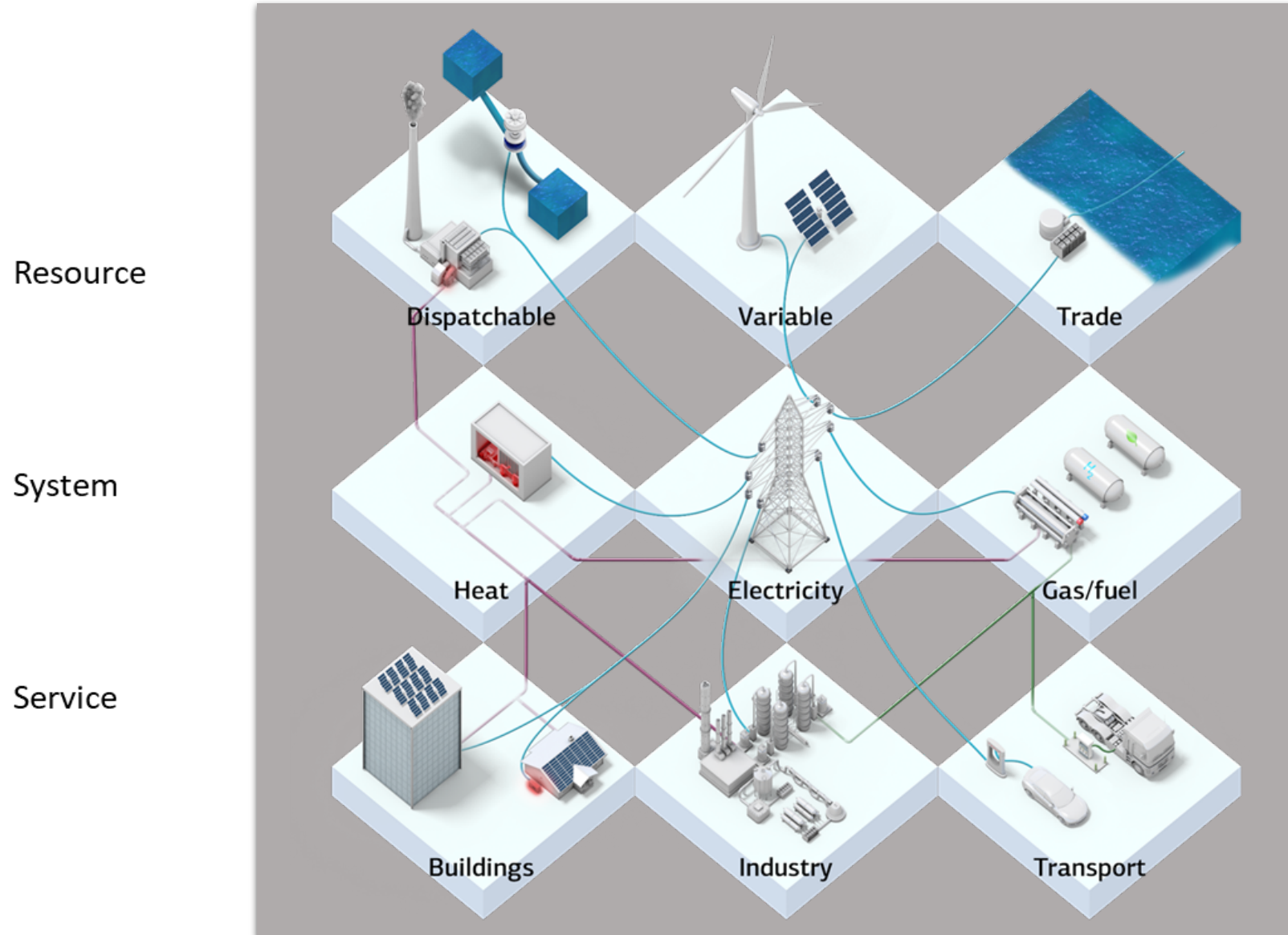
Demand responds



Flexibility in coupled infrastructures



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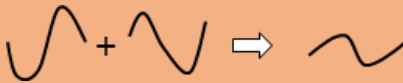

Sector coupling/
Electrification

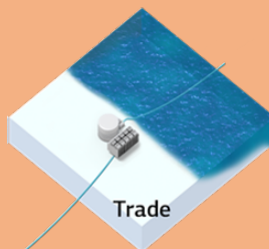
Demand responds

Flexibility by coupling

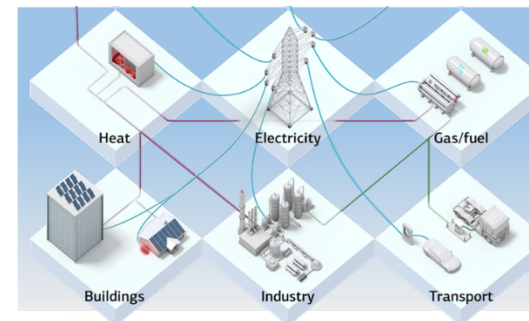


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	Coupling	Incentives for flexibility	Price variations	Driver	Impact
Transmission	Geographical coupling	Price differences between regions		Different technology mix	Increased imports and exports
Electricity/gas/heat Transport/storage	Sector coupling	Price differences between energy sources and technologies		Increased business opportunities	Increased national demand



Interconnection
Common frameworks
developed over the
last 3 decades



Sector coupling
Sector specific
frameworks

Sector coupling

Electrification as source of flexibility



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Nordic/Baltic
interview survey

Framework conditions

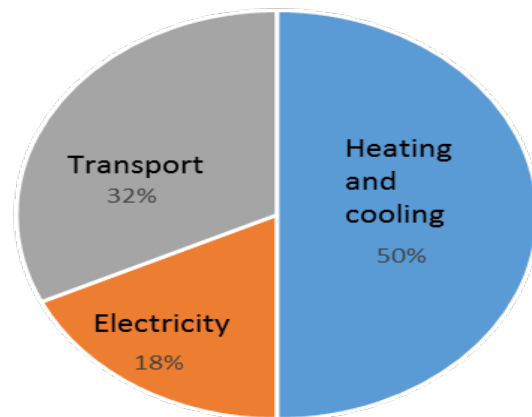
Market design

Direct regulation

Fiscal policies

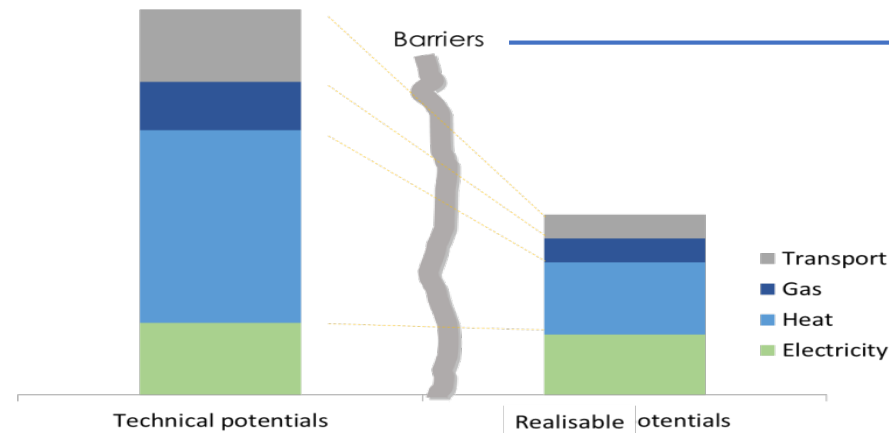
Support schemes

Grid regulation



Distribution of EU energy consumption
(Source: EU Heating and Cooling strategy)

From technical to realisable potentials



Large flexibility potentials in electrification of the energy sectors

Hindered by regulatory barriers

Remove barriers

- EU framework (Clean Energy for All Europeans)
- Nordic region greener than EU
- Traditional energy policy framework still dominate

Main barriers

B1 Insufficient market signals for some stakeholders;

B2 Uneven frameworks for different renewable energy resources.

Policy recommendations (Market-based policy framework):

R1 **Create a level playing field** for all RES technologies across sectors through consistent fiscal policies;

R2 Implement electricity **grid tariffs** which allow market signals for flexibility to reach the end-users;

R3 **Dynamic taxation** of electricity (e.g. restructuring levies and taxes);

R4 Encourage **VRE operators to act flexibly** using short-term market-based incentives;

R5 Abolish RES support during negative price periods;

R6 Enhance electrification by removing the limitations on using electricity for heating;

R7 Tackle investment risks in flexible individual heating through new financing and private ownership models.



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Policy Brief

**Better Policies
Accelerate Clean
Energy Transition**

Focus on energy system flexibility

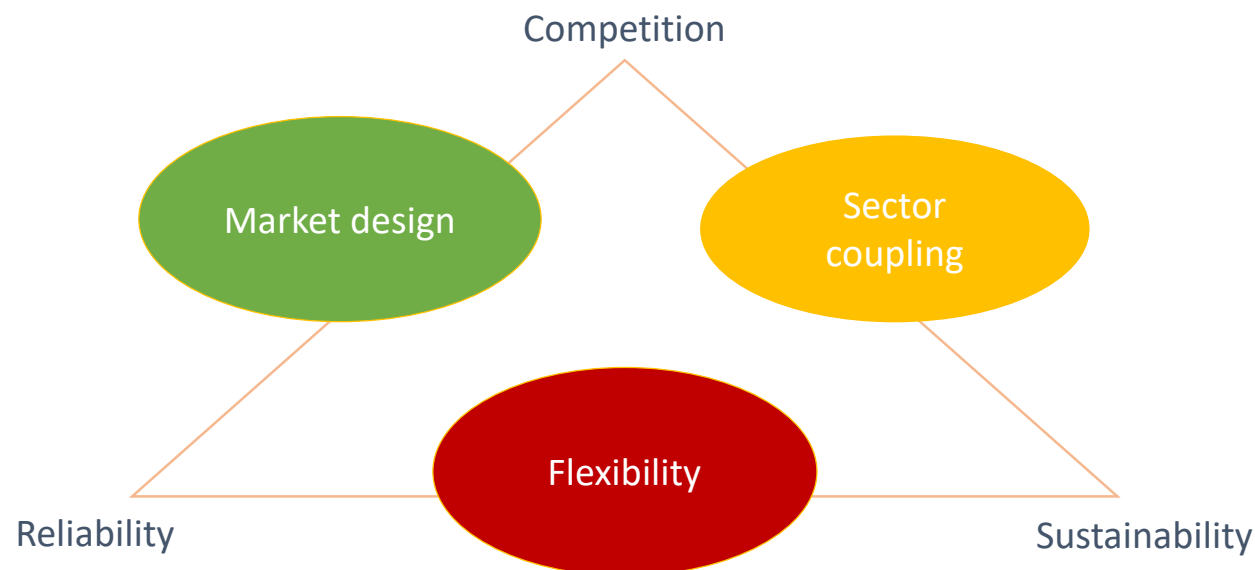
Nordic Energy
Research

Nordic commonalities with regional diversity

Recommendations	Related barrier(s)	Denmark	Norway	Sweden	Finland	Estonia	Latvia	Lithuania
R1	B2							
R2	B1							
R3	B1,B2							
R4	B1,B2							
R5	B1,B2							
R6	B2							
R7	B2							

B1 = Insufficient market signals for some stakeholders;
B2 = Uneven frameworks for different renewable energy resources

- All foresee an increase in VRE
- Common barriers, but specific conditions need consideration
- All have information deficit on flexibility and lacking policy awareness



Summary and next steps



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Transition to a 100% RES-based Nordic energy system is possible

- **Present system already relative flexible**
- **Policy awareness on flexibility** in addition to traditional environmental and cost related issues.
- **System** instead of individual sector approaches
- **Soft infrastructure** (Regulation/economics/institutions) as important as hard infrastructure
- Develop adequate **incentives**

Next steps / research questions

- Impact assessments/quantification
- Low hanging fruits / socio-economic least-costs solutions
- Technology and climate/environmental impact
- Pathways - Regulatory, technical and sustainable
- Policy recommendations



Questions?



www.Flex4RES.org

Klaus Skytte

Head of Energy
Economics and
Regulation

DTU, Denmark

klsk@dtu.dk



Extra slides



Scenarios



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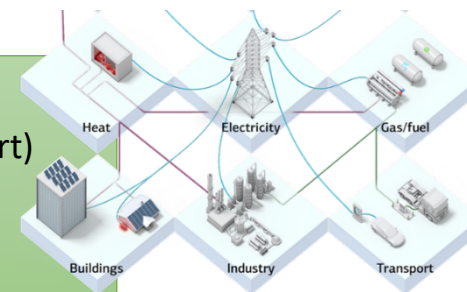
High sector coupling

Both transmission
and sector coupling



Sector coupling
(electrifying heat, gas, transport)

R1: Level playing field
R2/3: Tariffs & taxes



No targeted
incentives
for flexibility

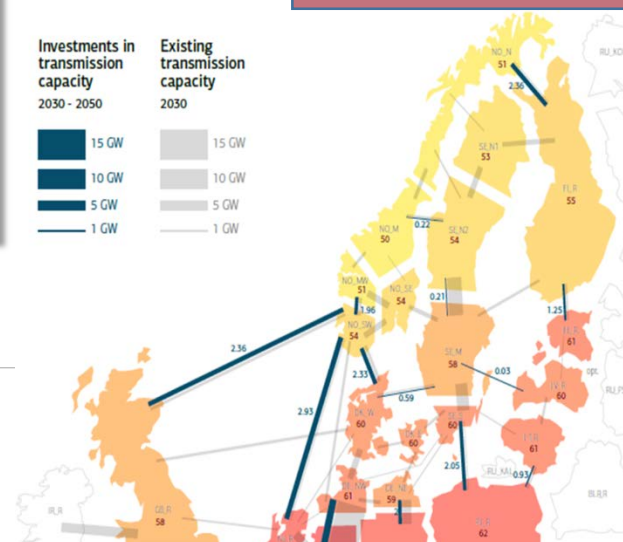
Targeted
incentives
for flexibility



Interconnection

Reference scenario
BAU

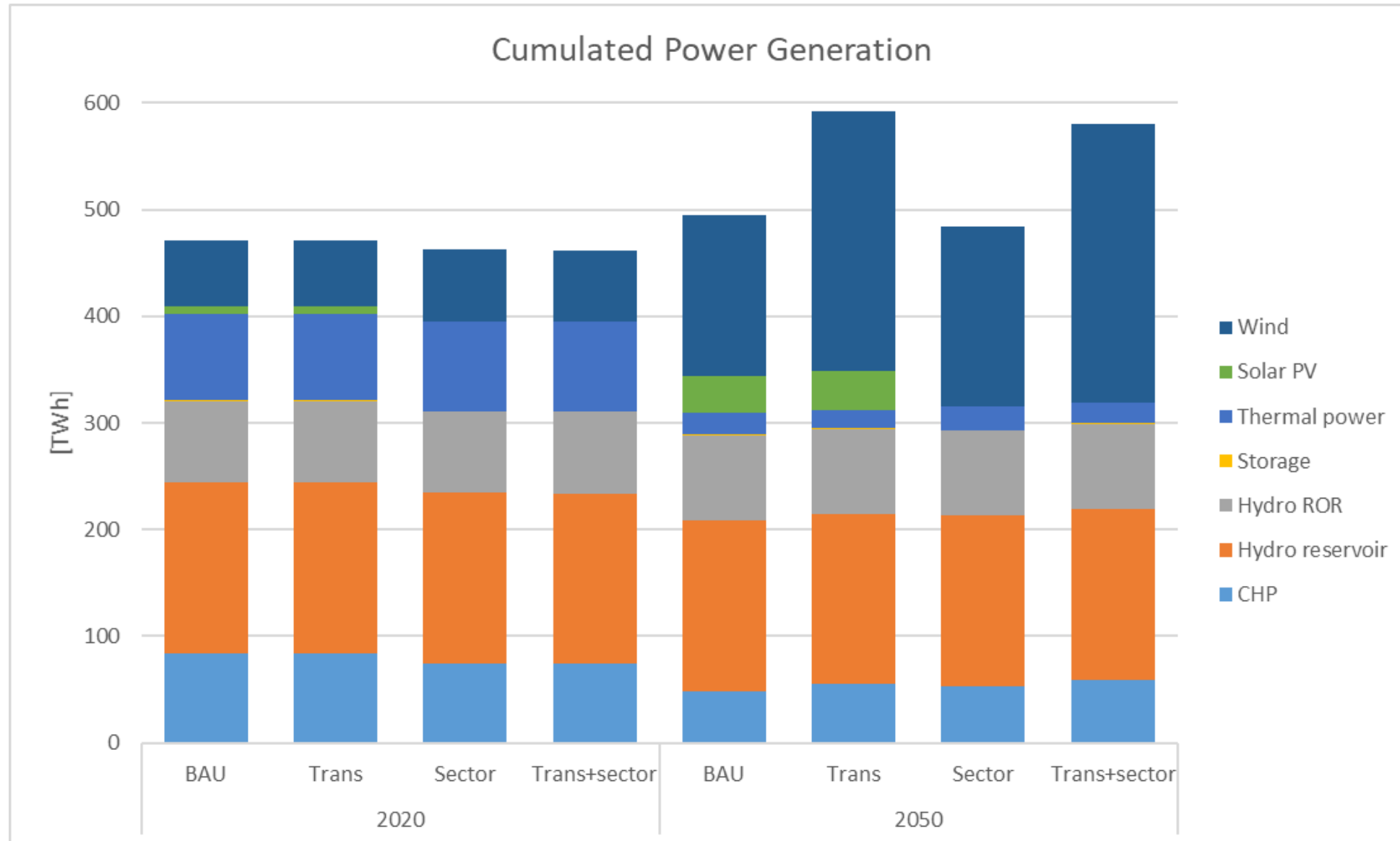
Low sector coupling



Scenario / model runs



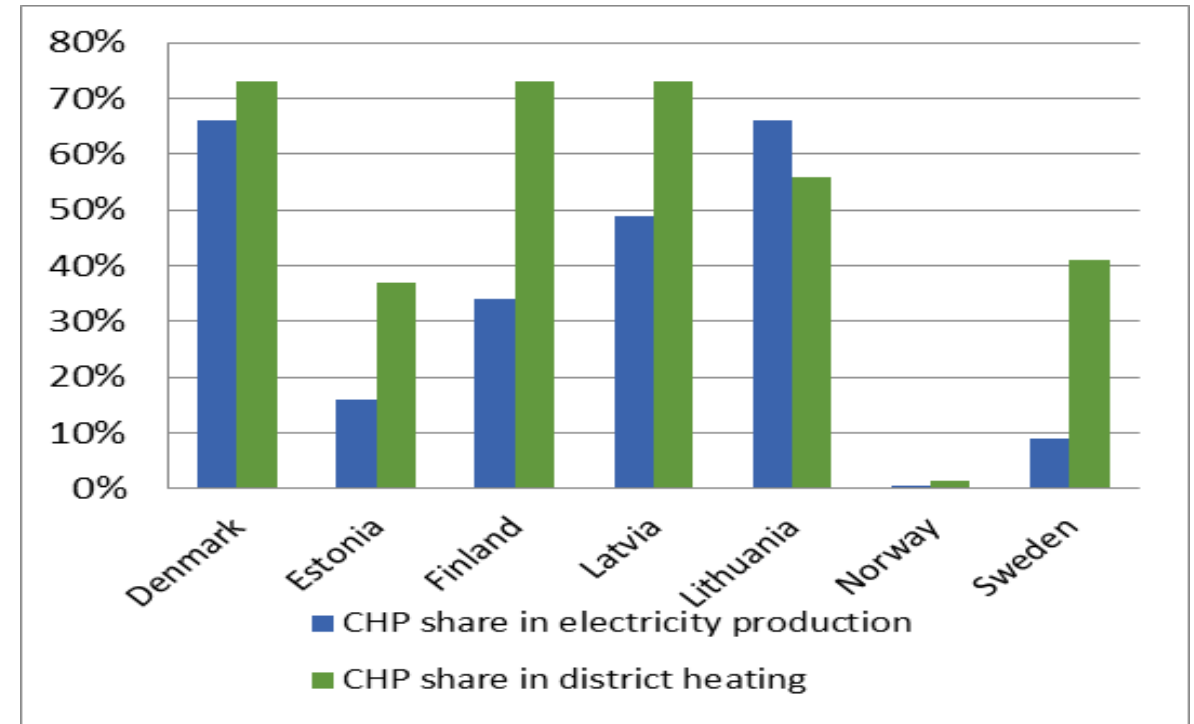
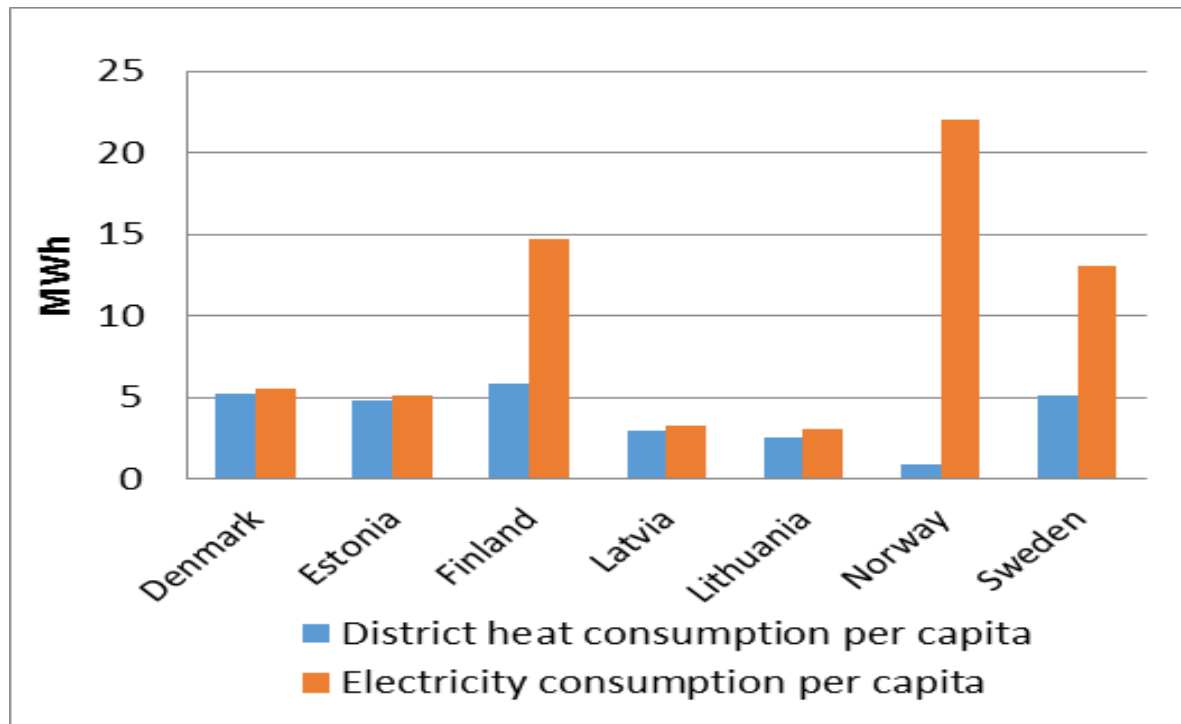
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District Heating in the Baltics/Nordics



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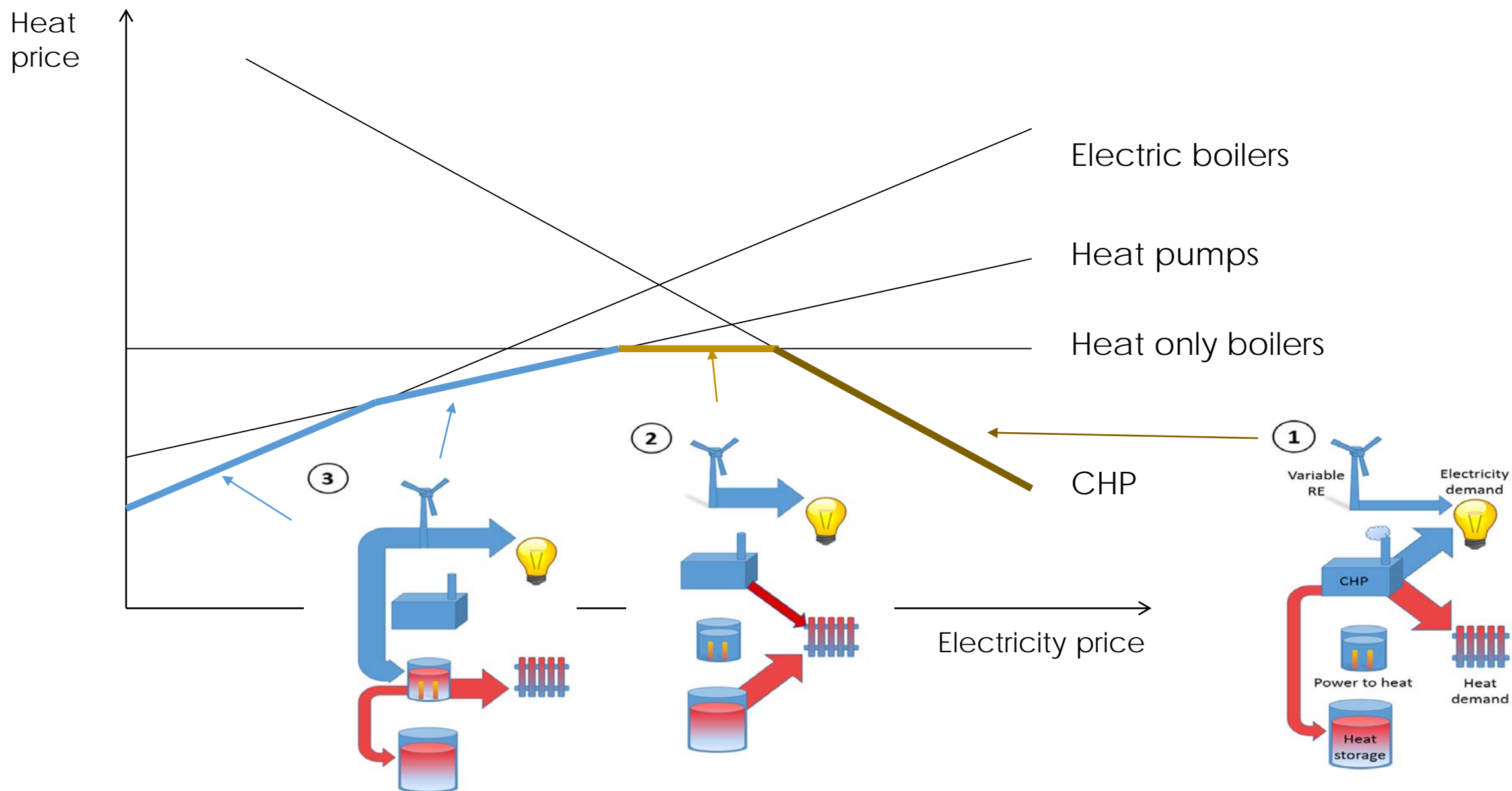
Source: Euroheat, 2015

District heating is widely used in most Baltic/Nordic countries and thus represents a flexibility source of considerable magnitude which is only partly exploited today by the power market

District heating-electricity interface



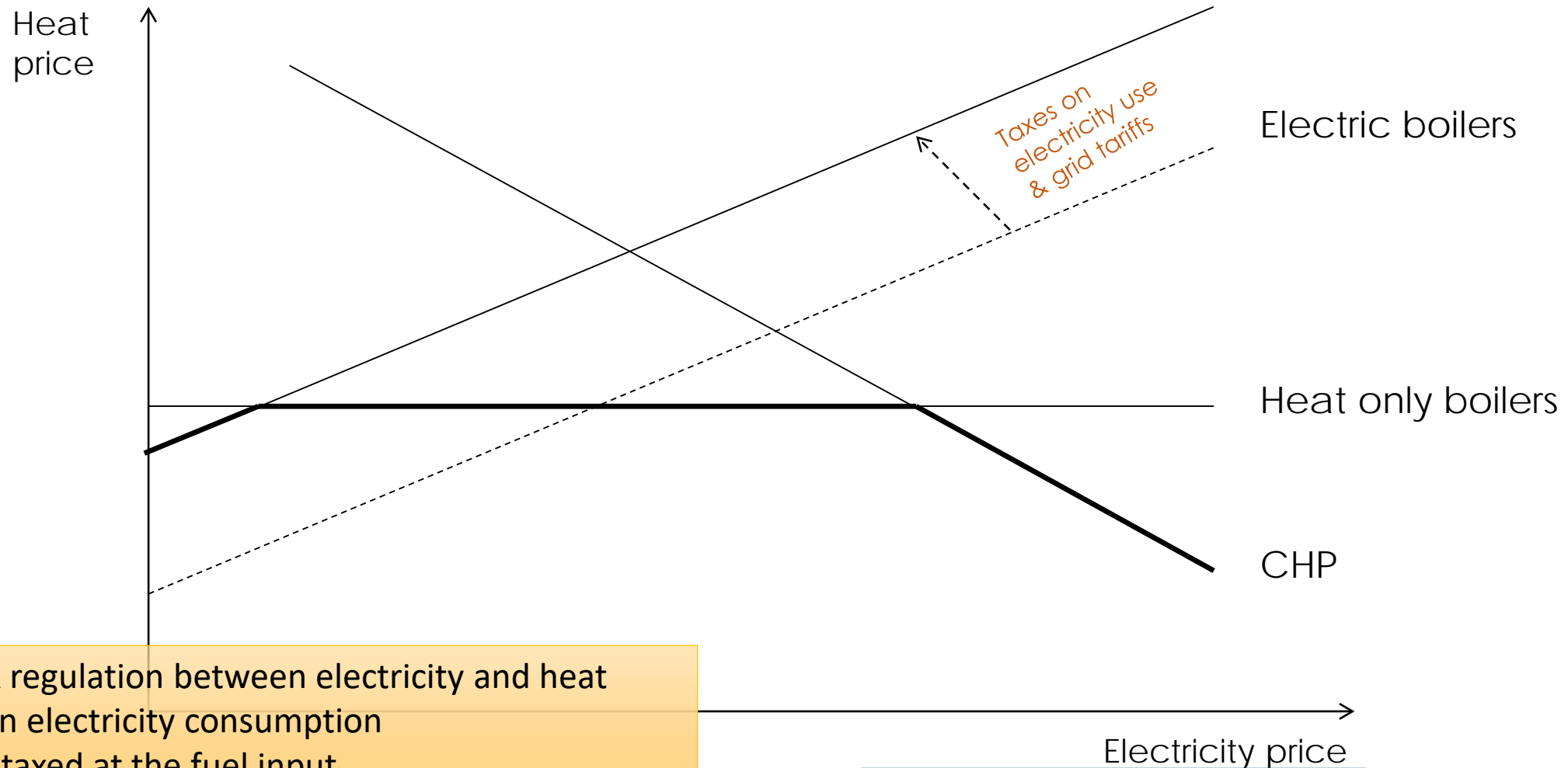
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Choice of heat supply - at different electricity prices



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Patchwork regulation between electricity and heat

- Taxes on electricity consumption
- Heat is taxed at the fuel input
- Biomass exempted for taxes



More heat only boilers.
Decoupling of electricity and heat
markets